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Washington, D. C. September 1941

PRELIMINARY COLOR STANDARDS AND COLOR NAMES FOR SOILS

By

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PRELIMINARY COLOR STANDARDS AND COLOR NAMES FOR SOILS

By T. D. RICE,[1] *senior soil scientist, Division of Soil Survey, Bureau of Plant Industry,* DOROTHY NICKERSON, *color technologist, Agricultural Marketing Service,* A. M. O'NEAL, *senior soil scientist, Division of Physical Surveys, Soil Conservation Service,* and JAMES THORP, *soil scientist, Division of Soil Survey, Bureau of Plant Industry*

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INTRODUCTION

Soil scientists in the United States have been studying the problem of establishing standards for soil colors for many years. At various times since 1920 the American Association of Soil Survey Workers (later the American Soil Survey Association that finally was merged with the Soil Section of the American Society of Agronomy to form the Soil Science Society of America) has had committees devoted to this question. From time to time these committees have reported upon the problem. The Division of Soil Survey and some of the State experiment stations have conducted researches (*4*, *7*, *11*, *12*)[2] leading toward the development of methods for measuring soil colors and the establishment of a standard nomenclature.

The first committee of the Association consisted of a single member, the late Prof. J. G. Hutton, who brought a report to the second meeting in 1921 (*1*). At that time a committee consisting of J. G. Hutton, Chairman, T. D. Rice, and A. M. O'Neal was appointed and this group worked on the problem. In 1922 the color committee (*3*) made an exhaustive study of the soil samples on file in Washington and selected and named a set of 32 color standards. The sets consisted of small quantities of soil in glass vials. In 1924 T. M. Bushnell was added to the committee.

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[1] Died August 23, 1939.

[2] Italic numbers in parentheses refer to Literature Cited, p. 11.

In 1925, a set of 20 soil-color standard names was reported by the committee (*2*). In 1927 (*5*) the committee brought in a report which recommended the matching of soil colors by the use of 4 Munsell disks. The report gave the technical data obtained from the National Bureau of Standards, United States Department of Commerce, that were necessary for standardization of the 4 disks and also gave a table of disk percentages required to match the color of a series of 59 soils deposited in the files of the Division of Soil Survey. The disk method of matching colors is a sound one and is now frequently used in soil work. Names for the colors were given, but they were not satisfactory.

J. A. Elwell was added to the committee in 1927 (*5*) and in 1930 the committee consisted of J. G. Hutton, T. M. Bushnell, A. B. Hoen, A. M. O'Neal, T. D. Rice, and Eric Winters. Bessie Hooppaw was named a member in 1930. The committee was discontinued the following year. From 1932 to 1939 there was no color committee in the Association, although former committee members carried on occasional correspondence on soil colors.

T. D. Rice continued the investigation of soil color and in 1936 assisted in the preparation of the Soil Survey Manual (published in September 1937) (*7*). Although the work had not proceeded to the point where it seemed wise to publish definite color standards, a significant and improved system of nomenclature was developed and included in the manual. About the same time C. F. Shaw published very similar suggestions, developed more or less independently on the basis of researches accomplished under his direction at the California Agricultural Experiment Station (*11*). The investigations were continued in the Department of Agriculture with the assistance at all times of Miss Dorothy Nickerson of the Color Measurements Laboratory (now a part of the Agricultural Marketing Service), with the view to developing definite color standards that could be published. A. M. O'Neal and James Thorp assisted in this work and after the death of T. D. Rice helped in carrying it to completion.

The work presented in this publication is the result of efforts by many people. It is still preliminary and revisions will doubtless be suggested when the standards are used. Comments will therefore be welcomed by the Division of Soil Survey in order that any subsequent editions may be more nearly complete and more useful.

DEVELOPMENT OF PRESENT RECOMMENDATIONS

The first step toward completing the dual problem of selecting color names and of preparing a chart of colors for use in soil investigations was the assembly of soil samples that would cover the range of colors needed. Two hundred and fifty samples were finally assembled. They were then measured in the color laboratory by placing each sample in a container, similar to the one shown in figure 1, and comparing it to the nearest Munsell color by means of a mask and charts, similar to those shown in figure 2. Two trained persons made these observations,[3] which were then averaged. The notations were given to tenths of a step of Munsell hue/value/chroma. These colors were then plotted in order to find the range covered by the samples. Figure 3 illustrates one of the methods used for plotting. It was found that the colors of the 250 samples ranged in hue from Munsell 7R to 5Y, in value from Munsell 2/ to 8/, and in chroma from Munsell /0.5 to /7.0.

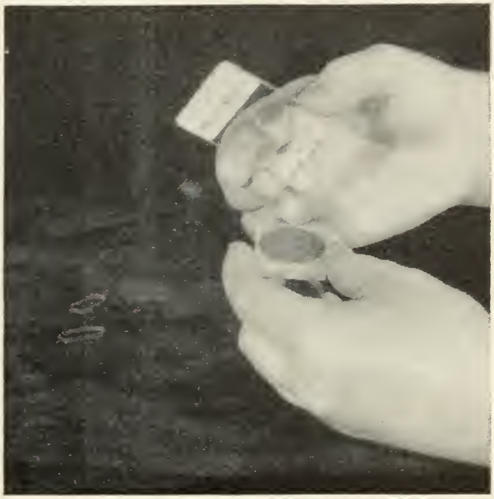

FIGURE 1.—Standard container used in preparing soil samples for color measurement.

The next step was to ascertain what names soil scientists gave to the colors of these samples. For that purpose a color-name questionnaire was prepared. The 250 samples were divided into sets of 50, each set selected to cover the full soil-color range. Soil scientists stationed in Washington or visiting there, and as many as possible of those attending the New Orleans meetings of the Soil

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[3] Thanks are hereby given to Kenneth L. Kelly, research associate of the American Pharmaceutical Association, working on color names for drugs and chemicals at the National Bureau of Standards, for making one set of these measurements.

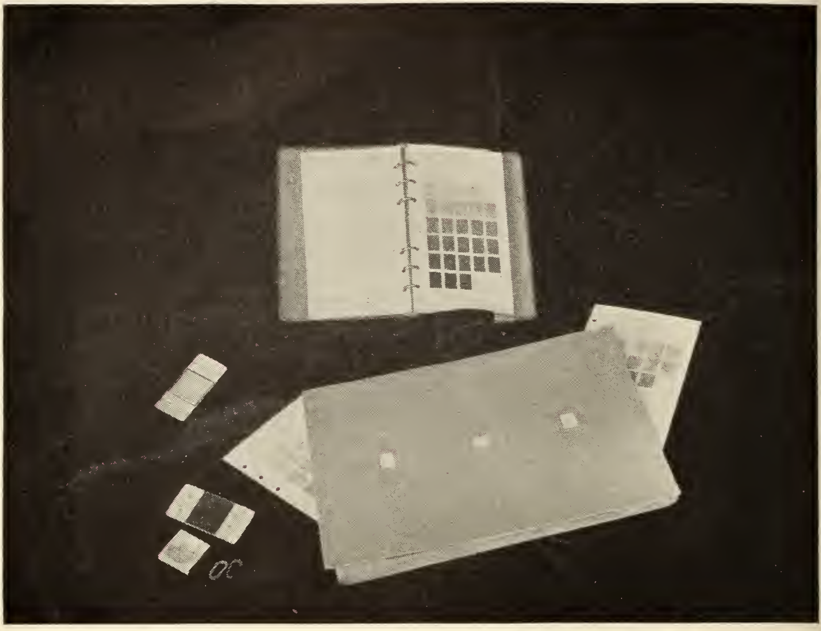

FIGURE 2.—Standard containers (one assembled, one unassembled) together with charts and mask used in color observations. The soil sample, in container, was placed behind the middle opening in the mask.

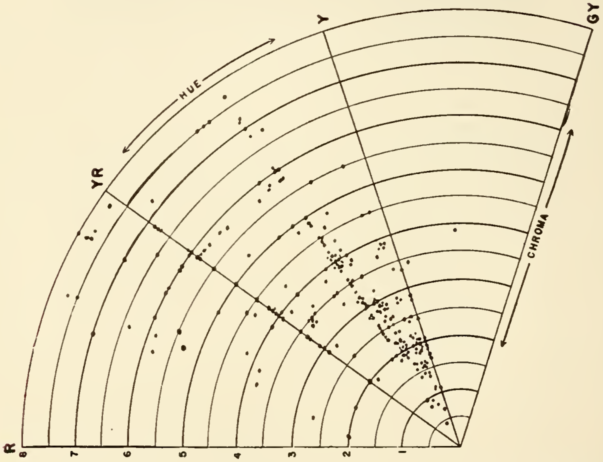

FIGURE 3.—Distribution of soil colors according to hue and chroma.

Science Society of America in 1939, were asked to name and record the colors of these samples. Over 50 scientists with field experience, representing all sections of the United States, and a few from other countries, took part in this work. Artificial daylight, about 60 foot-candles, at a color temperature approximating that of moderately overcast north sky[4] was used whenever possible for these tests, and black masks with holes about one-half by five-eighths inch were used over each sample, so that as far as possible each man had the colors of the soils presented to him with as many conditions standardized as was convenient.

There was little agreement on an exact name for each sample. It should, however, be noted that the names used generally followed the nomenclature suggested in the Soil Survey Manual. Only a very few odd or bizarre names were used. Observers quite generally limited themselves to the names red, pink, brown, yellow, olive, green, and combinations of these, together with gray, white, black, the adjective "ish" forms, and a few modifiers such as light, dark, dull, bright, pale, medium, and the adverb very. Occasionally, chocolate, salmon, brick red, buff, maroon, drab were used.

Even with the use of such acceptable color terms as those to which most observers limited themselves, there was little agreement on the exact color designation for any sample. The number of different designations given each sample and the number of observers for each of those samples is shown in table 1. The average number of different designations used for each of the 250 samples in the set was over 12.

Table 1.—*Number of samples to which specified numbers of different color names were applied by various groups of observers when 250 samples were grouped into 5 sets of 50 each*

Set 1, 22 observers		Set 2, 19 observers		Set 3, 24 observers		Set 4, 26 observers		Set 5, 21 observers	
Samples	Names	Samples	Names	Samples	Names	Samples	Names	Samples	Names
Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
1	7	1	5	2	6	1	6	3	9
1	8	2	6	1	7	1	8	5	10
5	9	1	7	3	8	4	9	10	11
6	10	6	8	6	10	3	10	8	12
4	11	7	9	5	11	5	11	9	13
2	12	3	10	8	12	2	12	7	14
13	13	7	11	6	13	7	13	1	15
8	14	9	12	2	14	8	14	2	16
5	15	6	13	7	15	7	15	2	17
4	16	4	14	9	16	4	16	2	18
1	17	3	15	1	18	2	17	1	19
		1	16			2	18		
						1	19		
						2	20		
						1	23		
50		50		50		50		50	

---

[4] In Washington, the naming was done under the artificial daylight illumination in the color laboratory, described in (*9*) and (*10*). In New Orleans, part of the work was done by a glass-block wall, north exposure (diffused daylight from 10 a. m. to 3 p. m. in late November), but most of it under a lamp similar in color quality to that of the Washington laboratory, loaned for this work during the convention through the courtesy of Norman Macbeth.

A few observers tried naming the same set of soil colors twice and were unable completely to duplicate names, though there were no great discrepancies.

The next step was to find a system of color names that could be sufficiently standardized to be acceptable to color scientists, sufficiently useful to be satisfactory to soil scientists, and sufficiently commonplace to be understood, at least in a general way, by the farmer. This definition paraphrases the problem proposed in 1931 by the United States Pharmacopoeial Revision Committee to the Inter-Society Color Council, a problem worked on during the 8 intervening years and answered in 1939 by a Method of Designating Colors published by the National Bureau of Standards (*6*) and recommended by the Inter-Society Color Council, and hereafter designated in this publication as the ISCC–NBS method.

THE ISCC–NBS METHOD OF DESIGNATING SOIL COLORS

The method is simple in principle. The terms "light," "medium," and "dark" designate decreasing degrees of lightness, and the adverb "very" is added to extend the lightness scale to "very light" and "very dark." The adjectives "weak," "medium," "strong," and "vivid" designate increasing degrees of chroma. In order that unwieldy adjective combinations shall not be required, the following terms are substituted for certain descriptions:

Term:	*Description*
Pale	For light and weak.
Brilliant	For light and strong.
Moderate	For medium, medium.
Dusky	For dark and weak.
Deep	For dark and strong.

These terms are used to modify the following hue or limited hue-range[5] names: pink, red, orange, brown, yellow, olive, green, blue, purple, and combinations of these formed by using two of them, as in blue green, or an "ish" suffix with one, as in purplish pink. For the neutral series, white, gray, and black are used.

The relationship of these names can be explained most easily by reference to what is known as a color solid. Because the three color attributes of any surface color may be represented in a three-dimensional solid, it is often called a surface-color solid.[6] The dimensions of this solid are hue, lightness,[7] and chroma,[8] diagrammatically represented in figure 4. The scale of lightness starts at the bottom of the figure, and is measured in lightness units from 0 at black, to 10 (or 100) at white. Hue is represented by an angle about the black-white axis, giving a closed series of red, yellow, green, blue, and purple, black to red, including all intermediate hues in their proper positions. Chroma is represented by distance from the black-white axis on a radius extending to the boundary of the solid, the grayest colors being near the center of the solid, the vivid colors at the surface of the solid.

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[5] Certain of the hue names cover all lightnesses and chromas, as in the case of green. But certain other hue names cover only a limited range of lightnesses and chromas, as the pinks, which are really very light reds, and the olives, which are actually dark yellows. But common usage is so strong in regard to such designations that the ISCC-NBS method has taken them into consideration and has applied different names to limited ranges of lightnesses and chromas of a single hue. To constant hues in certain yellow reds, the name brown is given to the dark group of colors, orange to those that are light and medium to strong in chroma, and orange pink to those for light and weak yellow reds. Brown, orange, and orange pink are then divided into several designations by the use of appropriate modifiers selected from those shown in figure 5.

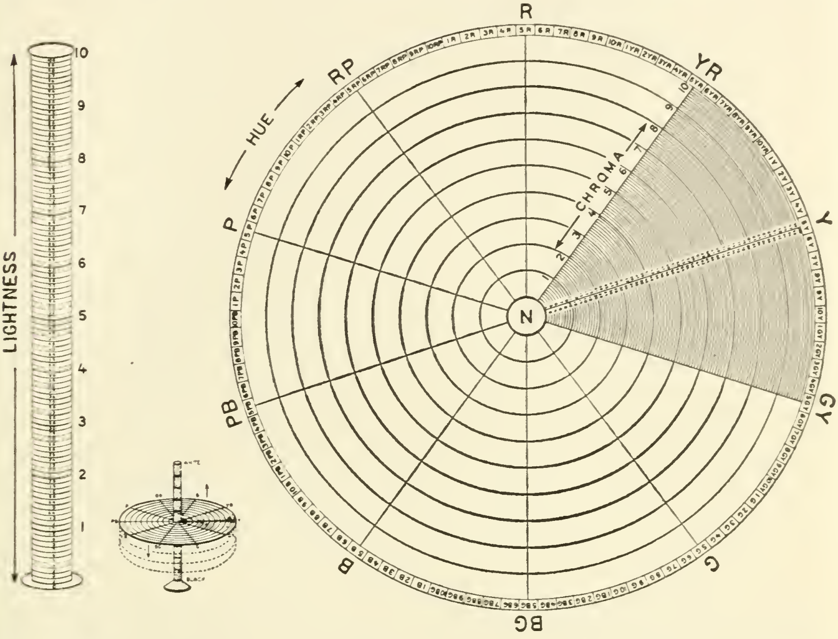

FIGURE 4.—Hue, lightness, and chroma in their three-dimensional relationship. The letters and numbers represent the Munsell notation.

The color designations of the ISCC–NBS method, therefore, define a block in the surface-color solid, and the complete system provides for 312 such blocks. This number is sufficient for naming colors from memory, but as it is estimated that man can distinguish over 10 million surface colors, it means that each block contains a number of distinguishable colors. When more than the number of names provided by this system is necessary, a system of numerical notation is advised, for number relationships can be remembered more easily than name relationships when the system must be extended to a greater number. Figure 5 is a section out of the color solid that includes the grays and purples.

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[6] Surface colors have black and white for the extremes of the lightness scale, whereas dim to brilliant may be the end points of a volume-color scale, as for colors of illuminants.

[7] Lightness is equivalent to Munsell value.

[8] Chroma is equivalent to saturation.

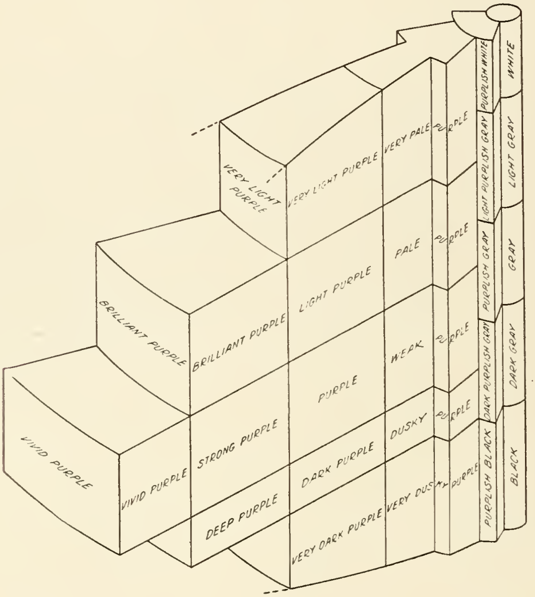

Figure 5.—A portion of the color solid including purples, grays, black, and white.

The boundaries of each name designation of the ISCC–NBS method are given in 34 charts included in the report of the National Bureau of Standards (*6*). For simplicity and ease of reference the limits are reported at the present time in terms of the Munsell color notation. It may be desirable ultimately to supplement this practical definition of limits for each color designation by giving equivalent definitions in terms of the 1931 internationally adopted (ICI) coordinate system, as this system does not depend upon a material set of standards. However, interpolation curves made available by the Color Laboratory of Agricultural Marketing Service[9] already permit a fairly reliable transfer from Munsell notation to ICI specifications, and it is expected that conversion tables of the colors in the Maerz and Paul Dictionary of Color (*8*) will soon be available in Munsell notation, thus enabling one to use the standard ISCC–NBS color names by reference to ICI, Maerz and Paul, or the Munsell system directly.

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[9] Nickerson, Dorothy. USE OF ICI TRISTIMULUS VALUES IN DISK COLORIMETRY. Agr. Marketing Serv., U. S. Dept. Agr. 1938. [Mimeographed preliminary report.]

ADOPTION OF ISCC–NBS METHOD FOR NAMING SOIL COLORS

The names in the ISCC–NBS method that cover the colors of soils have been selected for use as standard soil color names. The reasons are as follows: (1) There is at present a lack of uniformity in the use of color names among soil scientists; (2) the ISCC–NBS method fulfills the specifications laid down for a system of names for soil colors without upsetting any important usage of color names among soil scientists except by designating as reddish browns certain soils now usually called reds (any system of standards adopted would necessitate some change in custom by many workers); (3) the ISCC–NBS method seems to offer as little change as possible, as well as to provide a standardized method that will be recognized by groups other than those interested in soil-color names only.

In order to know what the range for soil colors should be in the ISCC–NBS color designations, the colors of the 250 samples originally assembled were given ISCC–NBS designations and assembled in charts to illustrate the range needed. The result indicated that about 57 names would be necessary. Samples of the average color representing these 57 names have been made up and appear on the 7 color charts that accompany this publication. The names of colors that fall outside of those needed for illustrating soil colors appear in the blocks that represent positions relative to the colors illustrated. For ease in making interpolations, the grayish colors are repeated on several charts.

As the charts are to be used in field work, they have been fastened together by a staple. By fastening them in this way the pages can be fanned out, as shown in figure 6, so that any single chart can be separated from the others. Holes have been cut adjacent to each color so that a soil sample may be placed behind the cut-out portion of the chart next to the color it most nearly matches.

Few soil colors will match perfectly the colors on the charts, but all colors should be easily located as nearer to one color than to another. The soil color should be called that of the color sample it most nearly matches. Those soil colors that seem to be halfway between two color samples on the chart may be designated by such expressions as "weak to moderate brown" or "pale to weak brown."

A notation for recording abbreviations of these color designations is given in table 2. Capital letters refer to the noun form of the hue name; lower case letters are used for the adjective form. As blue, brown, and black all begin with B, they are distinguished by writing the abbreviation B for blue, Br from brown. Bl for black. Green and gray are distinguished by using G for green, Gr for gray. Orange and olive are distinguished by using O for orange, Ol for olive.

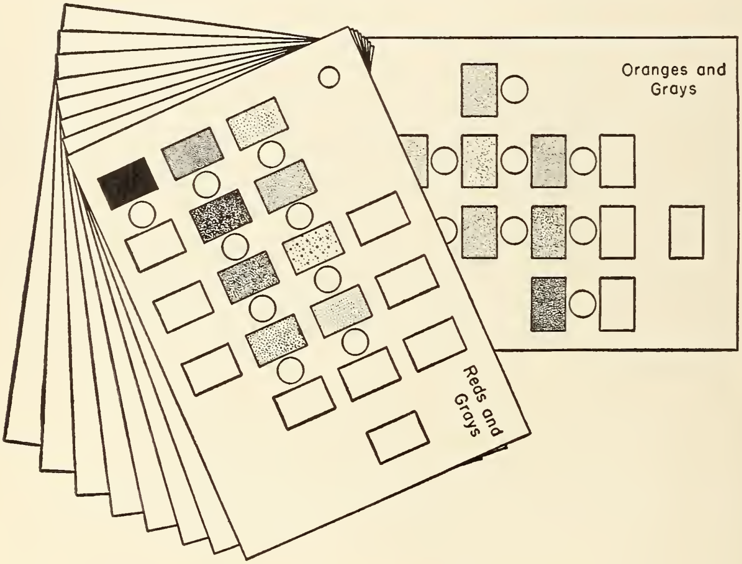

FIGURE 6.—Sketch of fanned-out color charts.

TABLE 2.—*Abbreviations for use with ISCC-NBS method of designating colors*

Noun form of hue	Adjective form of hue	Adjective modifiers	Adverb modifier
Pk=pink	pk=pinkish	lt=light	v=very.
R=red	r=reddish	dk=dark	
O=orange	o=orange	wk=weak	
Br=brown	br=brownish	str=strong	
Y=yellow	y=yellowish	mod=moderate	
Ol=olive	ol=olive	med=medium	
G=green	g=greenish	viv=vivid	
B=blue	b=bluish		
P=purple	p=purplish		
Wh=white			
Gr=gray			
Bl=black			

DISK MATCHING

Because there has been no satisfactory standard set of soil color names available, the disk method of matching soil colors has been widely used, and the color record often made in terms of disk percentages. Publication of the accompanying color charts will make disk matching unnecessary when it is used only for the purpose of obtaining a color record. In studies where differences smaller than those between the colors on these charts are important, it may still be desirable to obtain designations by the disk method. If the Munsell notation of the resultant match is calculated,[10] the ISCC-NBS color names can be ascertained quickly by reference to the 34 boundary charts of the color names given in the Bureau of Standards report (*6*) describing this method.

GENERAL REMARKS

Color standards were selected to match dry soil samples, but an attempt was made to select a wide enough range in lightness and chroma to cover both wet and dry soils. Soils frequently have different colors when wet than they have when dry (*12*), yet it is hoped the color range represented in the standards will be sufficient to cover nearly all conditions. After the standards have been used for some time, it may prove desirable to delete some and add others. Comments from field and laboratory workers will be welcomed.

As the preparation of these standards involves much hand work, and as the edition is limited, users are urged to exercise reasonable care in preserving them.

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[10] See footnote 9.

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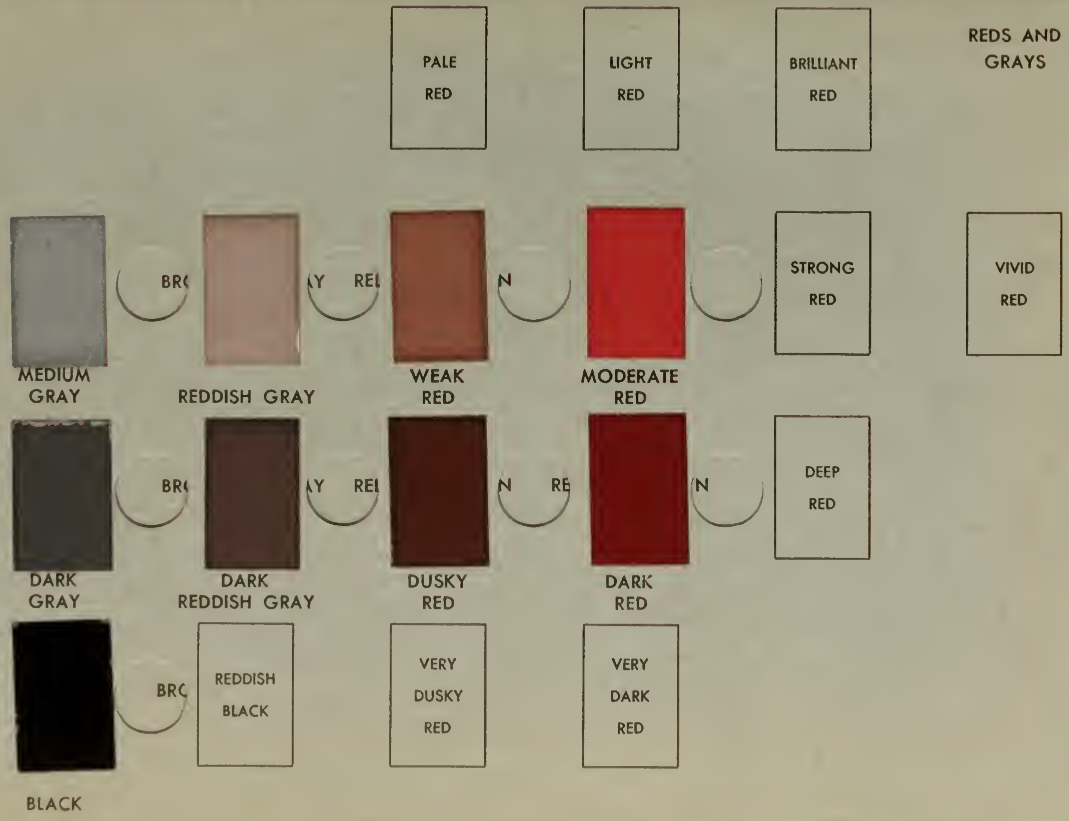
SOIL COLOR
NAME CHARTS

RED, ORANGE, REDDISH BROWN, BROWN,
YELLOWISH BROWN, OLIVE BROWN,
YELLOW, OLIVE, AND GRAYS WITH EACH

PREPARED BY
T. D. RICE, DOROTHY NICKERSON, A. M. O'NEAL AND JAMES THORP

6 pp.,

REDS AND GRAYS



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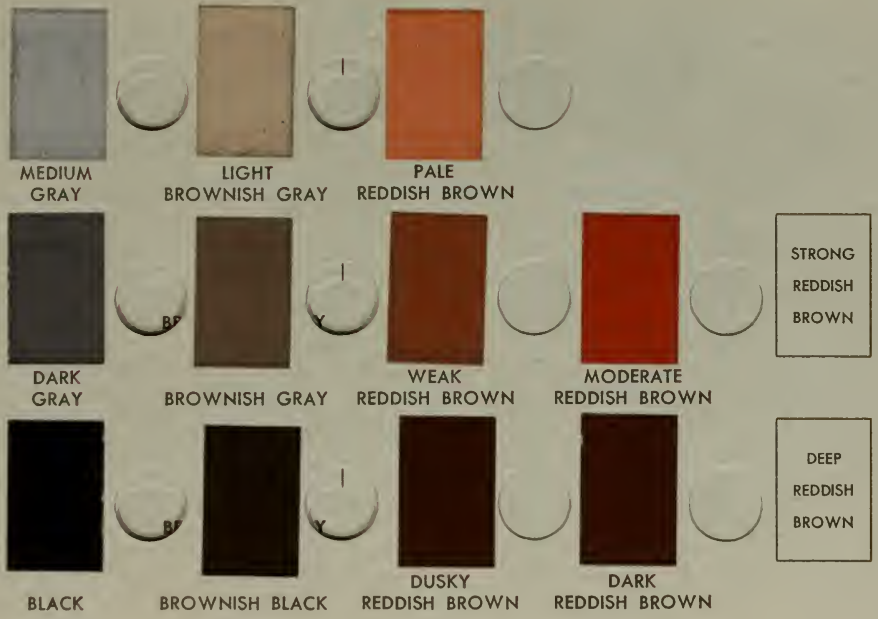

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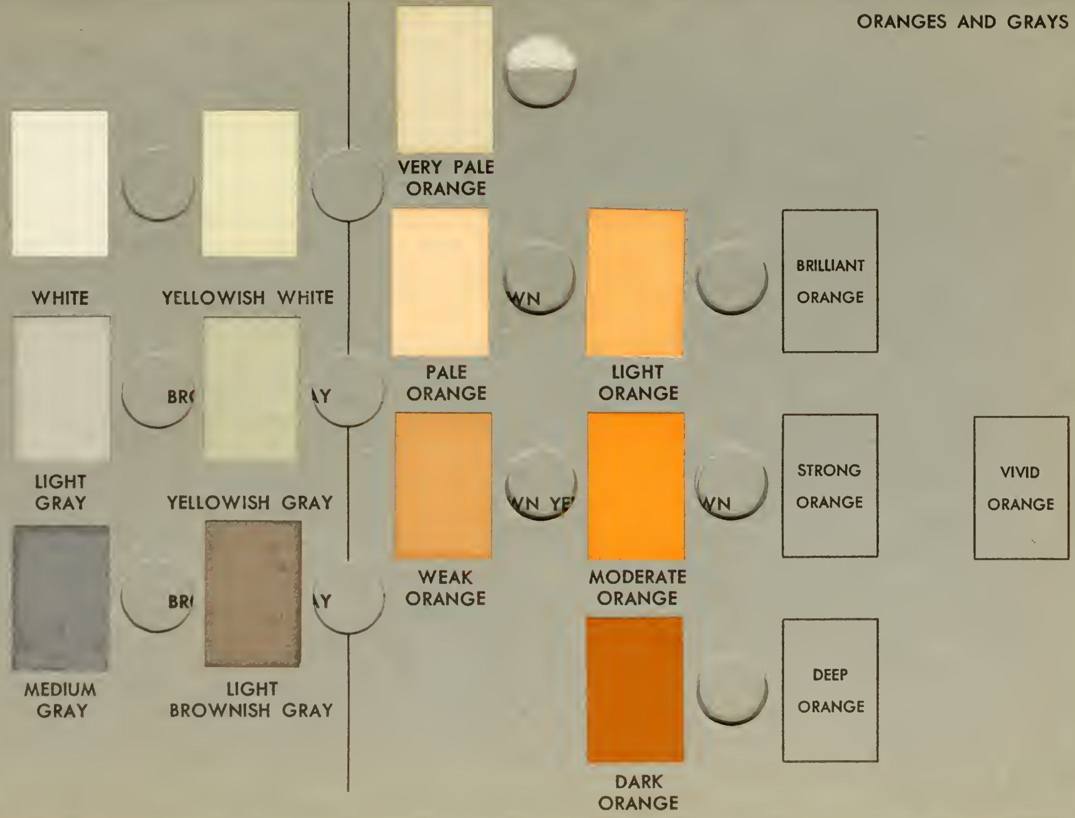

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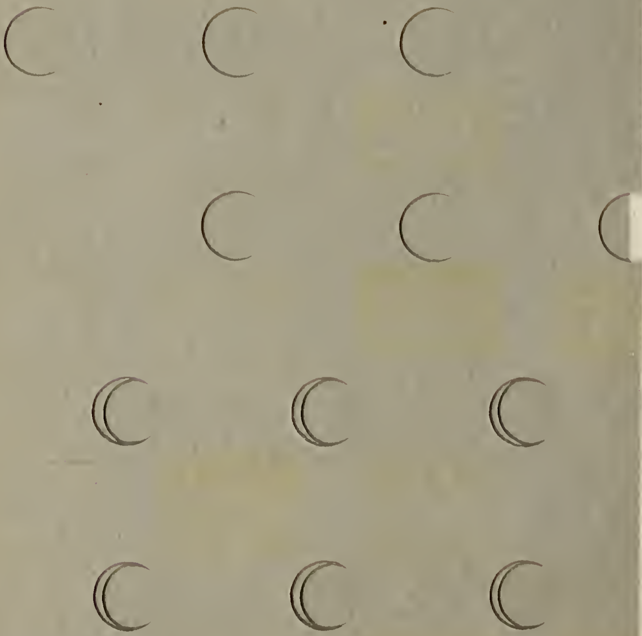

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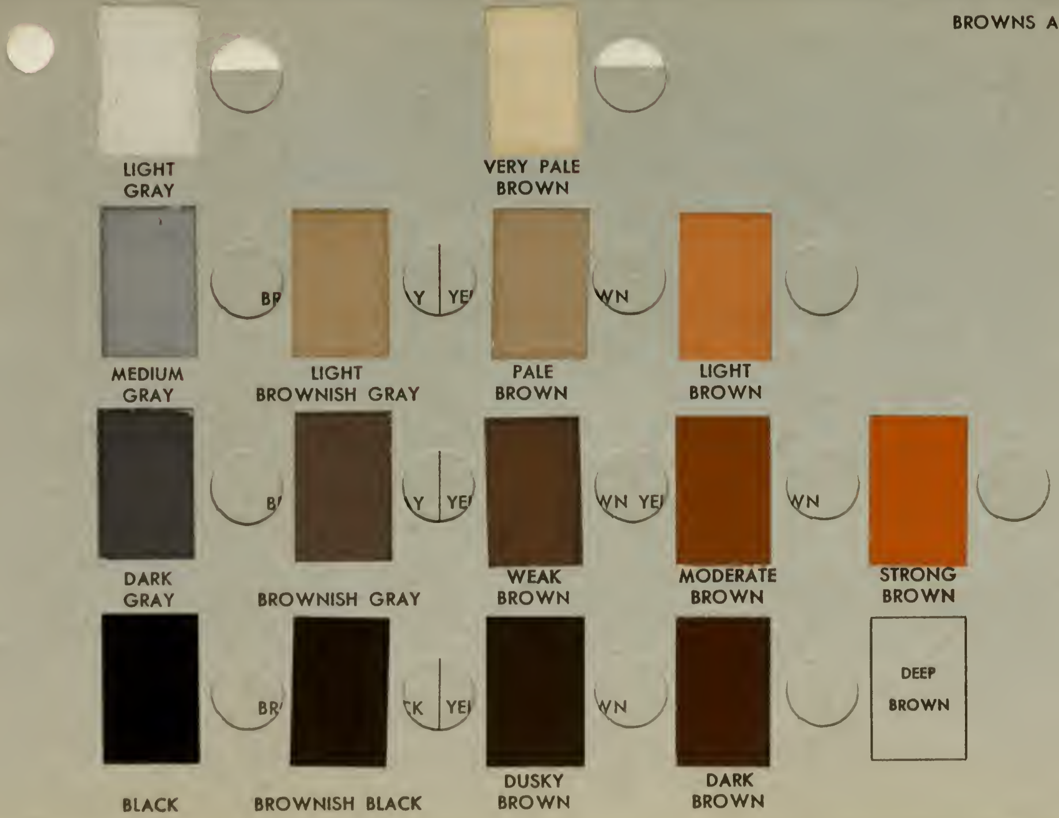

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YELLOWISH BROWNS
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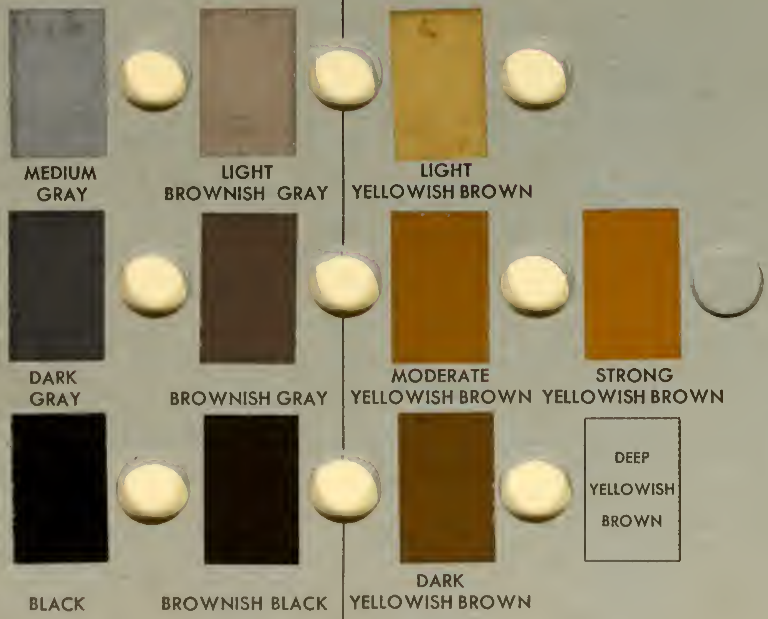

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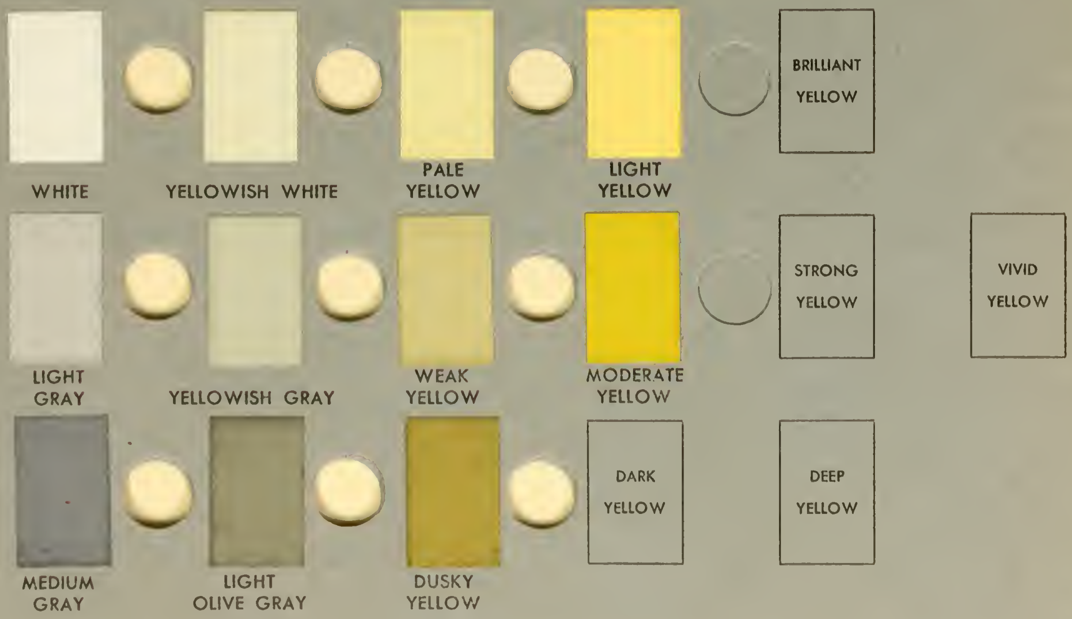

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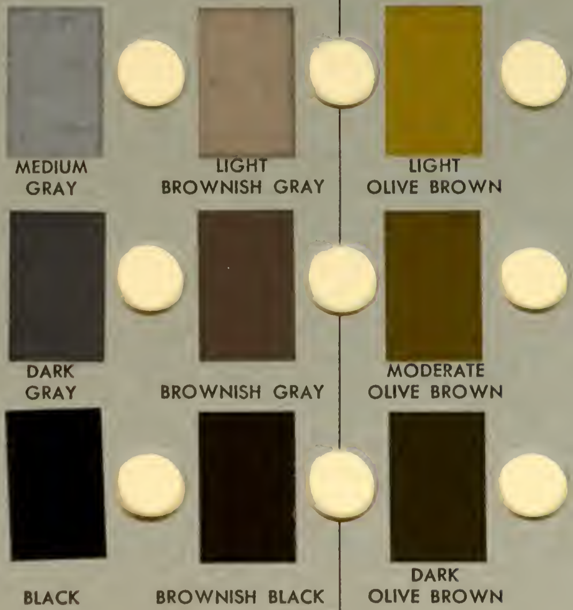

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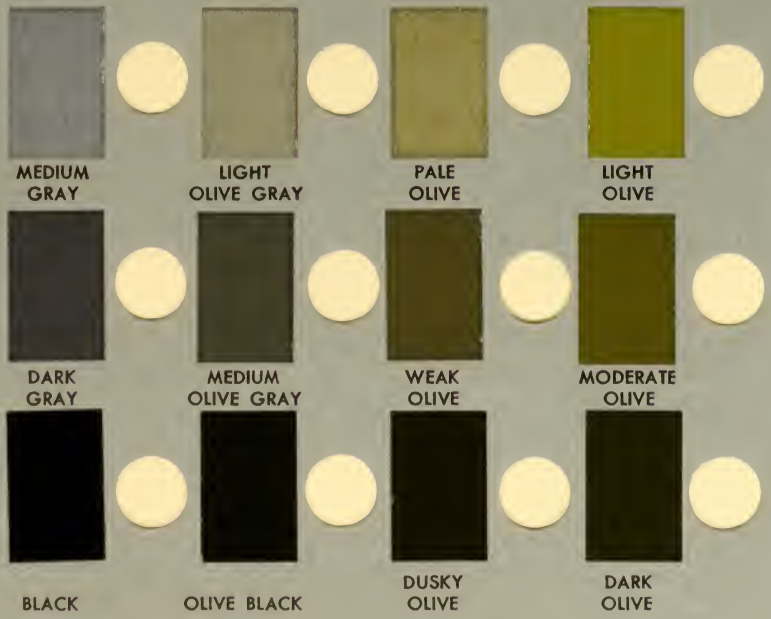

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